CLAIMS

1. A method comprising:

obtaining node-link data defining a node-link structure; the node-link structure including nodes and links, each link relating at least two of the nodes; and

using the node-link data to present a sequence of representations of the node-link structure on a display, the display having an edge along one side acting as a horizon; the sequence beginning with a first representation and ending with a last representation; the last representation being perceptible as a changed continuation of the first representation;

each representation in the sequence including bounded node features representing nodes in the node-link structure; each bounded node feature having a position and a region around the position;

the regions around the positions of the bounded node features in each representation together determining a first convex hull for the representation, each representation's first convex hull enclosing a total area for the representation;

the bounded node features of each representation including a subset of more spaced node features, the regions around the positions of the more spaced node features determining a second convex hull for the representation, each representation's second convex hull enclosing a sufficient portion of the representation's total area to serve as a focus on the nodes within the second convex hull, and enclosing a region in which bounded node features have nearest node spacings along an axis prependicular on the display to the horizon, that are in general perceptibly greater than in a region enclosed by the first convex hull but outside the second convex hull;

the nodes represented in at least one on the first and second representations forming at least one peripheral branch, each peripheral branch including a top level and at least one lower level, the top level including a top level node and the lower levels including lower level nodes that are not in the representation's subset of more spaced node features, each node at each lower level having a parent node at a next higher level to which the node is related through one link;

lower level node features that share a parent node feature having centers of area positioned on the display in order approximately along a line generally parallel with the horizon with sufficiently similar spacings along the axis perpendicular to the horizon from the region around the parent node feature and with sufficiently similar spacings in a dimension generally

parallel to said horizon from adjacent node features along the line that the lower level node features sharing the parent node feature are perceptible as a group of related node features;

the second convex hulls of the first and last representations including subsets of bounded node features that represent different sets of nodes; the sequence of representations producing a perception that at least one bounded node feature has a nearest node spacing that increases from the first representation to the last representation and that at least one other bounded node feature has a nearest node spacing that decreases from the first representation to the last representation.

2. The method of claim 1, wherein said horizon comprises a substantially vertical, straight line on said display.

3. The method of claim 1, wherein said horizon comprises a substantially horizontal, straight line on said display.

4. The method of claim 1, wherein said sufficient portion consists of about one-fourth to about three-fourths of the representation's total display area.

5. The method of claim 1, wherein said using the node-link data to present a sequence of representations includes:

storing hyperbolic layout data specifying positions of nodes in the node-link structure in a hyperbolic space;

accepting user input indicating a portion of said node-link structure for display;

using a half-plane model with compression to map said portion of the hyperbolic layout data for the portion of the node-link structure into display layout data; and

using said display layout data to display said first representation.

6. The method of claim 5, wherein the hyperbolic layout data comprises a data structure associated with a node in the node-link structure which includes parameters specifying a position in the hyperbolic space relative to a parent node.

7. The method of claim 5, wherein said using a half-plane model with compression includes:

mapping the portion of the hyperbolic layout data to an Euclidean space according to a half-plane model to produce Euclidean layout data; and

compressing the Euclidean layout data to yield the display layout data.

8. The method of claim 7, wherein the display layout data provides a displayable representation arranged for display in a substantially rectangular form factor.

9. The method of claim 5, wherein said laying out the node-link structure in a hyperbolic space, the hyperbolic space including a horizon, includes:

for each particular node to be displayed, determining a distance along a first axis generally perpendicular to the horizon between a parent node and the particular node, and determining an offset along a second axis generally parallel to the horizon from the parent node and the particular node.

10. The method of claim 5, wherein said laying out the node-link structure in a hyperbolic space, the hyperbolic space including a horizon, includes:

for each particular node to be displayed, determining a distance along a first axis generally perpendicular to the horizon between a parent node and the particular node, and determining an offset along a second axis generally parallel to the horizon from the parent node and the particular node, where said determining a distance includes determining a number of child nodes, including the particular node, associated with the parent, assigning a width along the second axis for each of said child nodes, and computing said distance in response to the widths of said child nodes.

11. The method of claim 5, wherein said laying out the node-link structure in a hyperbolic space, the hyperbolic space including a horizon, includes:

for each particular node to be displayed, determining a distance along a first axis generally perpendicular to the horizon between a parent node and the particular node, and determining an offset along a second axis generally parallel to the horizon from the parent node and the particular node, where said determining a distance includes determining a number of

child nodes, including said particular node, associated with the parent, assigning a width along the second axis for each of said child nodes, and computing said distance in response to the widths of said child nodes, so that there is enough space along said second axis to layout said child nodes, including said particular node, with the assigned widths.

12. The method of claim 5, wherein the hyperbolic layout data comprises a data structure associated with a node in the node-link structure which includes parameters specifying a position in the hyperbolic space relative to a another node, and wherein said accepting user input includes receiving an indication of a position in one of said hyperbolic space and said Euclidean space, finding a position of a first node in said hierarchy close to said indicated position, and then computing the positions of other nodes in said hierarchy relative to said first node, and displaying a changed representation based upon the position of said first node and of said other nodes.

13. The method of claim 5, wherein the hyperbolic layout data comprises a data structure associated with a node in the node-link structure which includes parameters specifying a position in the hyperbolic space relative to a another node, and wherein said accepting user input includes receiving an indication of a position of a first node in one of said hyperbolic and said Euclidean space, and then computing the positions of other nodes in said hierarchy relative to said first node and displaying a changed representation based upon the position of said first node and of said other nodes.

14. The method of claim 5, including displaying said displayable representation in a display area, wherein said accepting user input includes:

accepting signals pointing to a location in said display area; and

filtering said user input in response to said location in said display area to indicate a position in said hyperbolic space.

15. The method of claim 5, including displaying said displayable representation in a display area having side corresponding to a horizon in the hyperbolic space, wherein said accepting user input includes:

accepting signals pointing to a location in said display area; and

filtering said user input in response to said location in said display area to indicate a position in said hyperbolic space, including if said location is within a threshold distance in Euclidean space from the horizon, then signaling a position at a location spaced away from said side corresponding to the horizon.

16. The method of claim 5, including displaying said sequence of representations in a display area having a first side corresponding to a horizon in the hyperbolic space, a second side opposite the horizon, a first region adjacent said first side, a second region adjacent said second side, and a third region between the first and second regions, wherein said accepting user input includes:

accepting signals pointing to a location for a node in said display area; and

filtering said user input in response to said location in said display area to indicate a position in said hyperbolic space, including if said location is within said first region, then signaling a position at a location sufficiently spaced away from said first side and to allow for display of a child of said node within said display area.

17. The method of claim 5, including displaying said sequence of representations in a display area having a first side corresponding to a horizon in the hyperbolic space, and a second side opposite the horizon, wherein said accepting user input includes:

accepting signals pointing to a location for a node in said display area; and

filtering said user input in response to said location in said display area to indicate a position in said hyperbolic space, including if said location is within a threshold distance of the first side, then signaling a position at a location spaced away from said first side by a predetermined distance.

18. The method of claim 5, including displaying said sequence of representations in a display area having a first side corresponding to a horizon in the hyperbolic space, and a second side opposite the horizon, wherein said accepting user input includes:

accepting signals pointing to a location for a node in said display area; and

filtering said user input in response to said location in said display area to indicate a position in said hyperbolic space, including if said location is within a threshold distance of the

second side, then signaling a position at a location spaced away from said second side by a predetermined distance.

19. The method of claim 5, including displaying said sequence of representations in a display area having a first side corresponding to a horizon in the hyperbolic space, a second side opposite the horizon, a first region adjacent said first side, a second region adjacent said second side, and a third region between the first and second regions, wherein said accepting user input includes:

accepting signals pointing to a location for a node having a first representation located in said third region in said display area; and

filtering said user input in response to said location in said display area to indicate a position in said hyperbolic space, including if said location for said node is within said third region, then signaling a position which results in display of a second representation of said node at a location which shifted substantially vertically within said display area from said first representation.

20. A computer implemented method for providing a displayable representation of a hierarchy, comprising;

laying out the hierarchy in a hyperbolic space to produce hyperbolic layout data for the hierarchy; and

using a half-plane model with compression to map a portion of the hyperbolic layout data for the hierarchy to display layout data; and

storing or transmitting said display layout data for use in displaying said displayable representation.

21. The method of claim 20, wherein the hierarchy comprises a node-link structure, and the hyperbolic layout data comprises a data structure associated with a node in the node-link structure which includes parameters specifying a position in the hyperbolic space relative to a parent node.

22. The method of claim 20, wherein said using a half-plane model with compression includes:

mapping the portion of the hyperbolic layout data to an Euclidean space according to a half-plane model to produce Euclidean layout data; and

compressing the Euclidean layout data to yield the display layout data to provide a displayable representation of the portion of the hierarchy.

23. The method of claim 22, wherein the display layout data provides a displayable representation arranged for display in a substantially rectangular form factor.

24. The method of claim 20, wherein said laying out the hierarchy in a hyperbolic space includes:

for each particular node in the hierarchy to be displayed, determining a distance along a first axis between a parent node and the particular node, and determining an offset along a second axis from the parent node and the particular node.

25. The method of claim 20, wherein said laying out the hierarchy in a hyperbolic space, the hyperbolic space including a horizon, includes:

for each particular node in the hierarchy to be displayed, determining a distance along a first axis generally perpendicular to the horizon between a parent node and the particular node, and determining an offset along a second axis generally parallel to the horizon from the parent node and the particular node, where said determining a distance includes determining a number of child nodes associated with the parent, assigning a width along the second axis for each of said child nodes, and computing said distance in response to the widths of said child nodes.

26. The method of claim 20, wherein said laying out the hierarchy in a hyperbolic space, the hyperbolic space including a horizon, includes:

for each particular node in the hierarchy to be displayed, determining a distance along a first axis generally perpendicular to the horizon between a parent node and the particular node, and determining an offset along a second axis generally parallel to the horizon from the parent node and the particular node, where said determining a distance includes determining a number of child nodes associated with the parent, assigning a width along the second axis for each of said child nodes, and computing said distance in response to the widths of said child

nodes, so that there is enough space along said second axis to layout said child nodes, including said particular node, with the assigned widths.

27. The method of claim 20, wherein the hierarchy comprises a node-link structure, and the hyperbolic layout data comprises a data structure associated with a node in the node-link structure which includes parameters specifying a position in the hyperbolic space relative to a another node, and wherein said using a half-plane model with compression to map a portion of the hyperbolic layout data for the hierarchy to display layout data, includes determining a position in one of said hyperbolic space and said Euclidean space, finding a position of a first node in said hierarchy close to said position, and then computing the positions of other nodes in said hierarchy relative to said first node using said hyperbolic layout data.

28. The method of claim 20, wherein the hierarchy comprises a node-link structure, and the hyperbolic layout data comprises a data structure associated with a node in the node-link structure which includes parameters specifying a position in the hyperbolic space relative to a another node, and wherein said using a half-plane model with compression to map a portion of the hyperbolic layout data for the hierarchy to display layout data, includes determining a position of a first node in one of said hyperbolic and said Euclidean space, and then computing the positions of other nodes in said hierarchy relative to said first node.

29. A computer implemented method for providing a displayable representation of a hierarchy, comprising;

storing hyperbolic layout data specifying positions of nodes in the hierarchy in a hyperbolic space;

accepting user input indicating a portion of said hierarchy for display;

using a half-plane model with compression to map said portion of the hyperbolic layout data for the hierarchy into display layout data; and

using said display layout data to display said displayable representation.

30. The method of claim 29, wherein the hierarchy comprises a node-link structure, and the hyperbolic layout data comprises a data structure associated with a node in the

node-link structure which includes parameters specifying a position in the hyperbolic space relative to a parent node.

31. The method of claim 29, wherein said using a half-plane model with compression includes:

mapping the portion of the hyperbolic layout data to an Euclidean space according to a half-plane model to produce Euclidean layout data; and

compressing the Euclidean layout data to yield the display layout data.

32. The method of claim 31, wherein the display layout data provides a displayable representation arranged for display in a substantially rectangular form factor.

33. The method of claim 29, wherein said laying out the hierarchy in a hyperbolic space, the hyperbolic space including a horizon, includes:

for each particular node in the hierarchy to be displayed, determining a distance along a first axis generally perpendicular to the horizon between a parent node and the particular node, and determining an offset along a second axis generally parallel to the horizon from the parent node and the particular node.

34. The method of claim 29, wherein said laying out the hierarchy in a hyperbolic space, the hyperbolic space including a horizon, includes:

for each particular node in the hierarchy to be displayed, determining a distance along a first axis generally perpendicular to the horizon between a parent node and the particular node, and determining an offset along a second axis generally parallel to the horizon from the parent node and the particular node, where said determining a distance includes determining a number of child nodes, including the particular node, associated with the parent, assigning a width along the second axis for each of said child nodes, and computing said distance in response to the widths of said child nodes.

35. The method of claim 29, wherein said laying out the hierarchy in a hyperbolic space, the hyperbolic space including a horizon, includes:

for each particular node in the hierarchy to be displayed, determining a distance along a first axis generally perpendicular to the horizon between a parent node and the particular node, and determining an offset along a second axis generally parallel to the horizon from the parent node and the particular node, where said determining a distance includes determining a number of child nodes, including said particular node, associated with the parent, assigning a width along the second axis for each of said child nodes, and computing said distance in response to the widths of said child nodes, so that there is enough space along said second axis to layout said child nodes, including said particular node, with the assigned widths.

36. The method of claim 29, wherein the hierarchy comprises a node-link structure, and the hyperbolic layout data comprises a data structure associated with a node in the node-link structure which includes parameters specifying a position in the hyperbolic space relative to a another node, and wherein said accepting user input includes receiving an indication of a position in one of said hyperbolic space and said Euclidean space, finding a position of a first node in said hierarchy close to said indicated position, and then computing the positions of other nodes in said hierarchy relative to said first node, and displaying a changed representation based upon the position of said first node and of said other nodes.

37. The method of claim 29, wherein the hierarchy comprises a node-link structure, and the hyperbolic layout data comprises a data structure associated with a node in the node-link structure which includes parameters specifying a position in the hyperbolic space relative to a another node, and wherein said accepting user input includes receiving an indication of a position of a first node in one of said hyperbolic and said Euclidean space, and then computing the positions of other nodes in said hierarchy relative to said first node and displaying a changed representation based upon the position of said first node and of said other nodes.

38. The method of claim 29, including displaying said displayable representation in a display area, wherein said accepting user input includes:

accepting signals pointing to a location in said display area; and

filtering said user input in response to said location in said display area to indicate a position in said hyperbolic space.

39. The method of claim 29, including displaying said displayable representation in a display area having side corresponding to a horizon in the hyperbolic space, wherein said accepting user input includes:

accepting signals pointing to a location in said display area; and

filtering said user input in response to said location in said display area to indicate a position in said hyperbolic space, including if said location is within a threshold distance in Euclidean space from the horizon, then signaling a position at a location spaced away from said side corresponding to the horizon.

40. The method of claim 29, including displaying said sequence of representations in a display area having a first side corresponding to a horizon in the hyperbolic space, a second side opposite the horizon, a first region adjacent said first side, a second region adjacent said second side, and a third region between the first and second regions, wherein said accepting user input includes:

accepting signals pointing to a location for a node in said display area; and

filtering said user input in response to said location in said display area to indicate a position in said hyperbolic space, including if said location is within said first region, then signaling a position at a location sufficiently spaced away from said first side and to allow for display of a child of said node within said display area.

41. The method of claim 29, including displaying said sequence of representations in a display area having a first side corresponding to a horizon in the hyperbolic space, and a second side opposite the horizon, wherein said accepting user input includes:

accepting signals pointing to a location for a node in said display area; and

filtering said user input in response to said location in said display area to indicate a position in said hyperbolic space, including if said location is within a threshold distance of the first side, then signaling a position at a location spaced away from said first side by a predetermined distance.

42. The method of claim 29, including displaying said sequence of representations in a display area having a first side corresponding to a horizon in the hyperbolic space, and a second side opposite the horizon, wherein said accepting user input includes:

accepting signals pointing to a location for a node in said display area; and

filtering said user input in response to said location in said display area to indicate a position in said hyperbolic space, including if said location is within a threshold distance of the second side, then signaling a position at a location spaced away from said second side by a predetermined distance.

43. The method of claim 29, including displaying said sequence of representations in a display area having a first side corresponding to a horizon in the hyperbolic space, a second side opposite the horizon, a first region adjacent said first side, a second region adjacent said second side, and a third region between the first and second regions, wherein said accepting user input includes:

accepting signals pointing to a location for a node having a first representation located in said third region in said display area; and

filtering said user input in response to said location in said display area to indicate a position in said hyperbolic space, including if said location for said node is within said third region, then signaling a position which results in display of a second representation of said node at a location which shifted substantially vertically within said display area from said first representation.

44. An article of manufacture comprising:

a machine readable data storage medium, having stored thereon a computer program including instructions used upon execution by a computer for performing steps including:

obtaining node-link data defining a node-link structure; the node-link structure including nodes and links, each link relating at least two of the nodes; and

using the node-link data to present a sequence of representations of the node-link structure on a display, the display having an edge along one side acting as a horizon; the sequence beginning with a first representation and ending with a last representation; the last representation being perceptible as a changed continuation of the first representation;

each representation in the sequence including bounded node features representing nodes in the node-link structure; each bounded node feature having a position and a region around the position;

the regions around the positions of the bounded node features in each representation together determining a first convex hull for the representation, each representation's first convex hull enclosing a total area for the representation;

the bounded node features of each representation including a subset of more spaced node features, the regions around the positions of the more spaced node features determining a second convex hull for the representation, each representation's second convex hull enclosing a sufficient portion of the representation's total area to serve as a focus on the nodes within the second convex hull, and enclosing a region in which bounded node features have nearest node spacings along an axis prependicular on the display to the horizon, that are in general perceptibly greater than in a region enclosed by the first convex hull but outside the second convex hull;

the nodes represented in at least one on the first and second representations forming at least one peripheral branch, each peripheral branch including a top level and at least one lower level, the top level including a top level node and the lower levels including lower level nodes that are not in the representation's subset of more spaced node features, each node at each lower level having a parent node at a next higher level to which the node is related through one link;

lower level node features that share a parent node feature having centers of area positioned on the display in order approximately along a line generally parallel with the horizon with sufficiently similar spacings along the axis perpendicular to the horizon from the region around the parent node feature and with sufficiently similar spacings in a dimension generally parallel to said horizon from adjacent node features along the line that the lower level node features sharing the parent node feature are perceptible as a group of related node features;

the second convex hulls of the first and last representations including subsets of bounded node features that represent different sets of nodes; the sequence of representations producing a perception that at least one bounded node feature has a nearest node spacing that increases from the first representation to the last representation and that at least one other bounded node feature has a nearest node spacing that decreases from the first representation to the last representation.

45. An apparatus comprising:

memory;

user input circuitry for providing data indicating signals from a user;

a display;

a processor coupled to the memory, the user input circuitry and the display;

node-link data stored in said memory, the node-link data defining a node-link structure, the node-link structure including nodes and links, each link relating at least two of the nodes; and

resources coupled with the processor for using the node-link data to present a sequence of representations of the node-link structure on the display, the display having an edge along one side acting as a horizon; the sequence beginning with a first representation and ending with a last representation; the last representation being perceptible as a changed continuation of the first representation;

each representation in the sequence including bounded node features representing nodes in the node-link structure; each bounded node feature having a position and a region around the position;

the regions around the positions of the bounded node features in each representation together determining a first convex hull for the representation, each representation's first convex hull enclosing a total area for the representation;

the bounded node features of each representation including a subset of more spaced node features, the regions around the positions of the more spaced node features determining a second convex hull for the representation, each representation's second convex hull enclosing a sufficient portion of the representation's total area to serve as a focus on the nodes within the second convex hull, and enclosing a region in which bounded node features have nearest node spacings along an axis prependicular on the display to the horizon, that are in general perceptibly greater than in a region enclosed by the first convex hull but outside the second convex hull;

the nodes represented in at least one on the first and second representations forming at least one peripheral branch, each peripheral branch including a top level and at least one lower level, the top level including a top level node and the lower levels including lower level nodes that are not in the representation's subset of more spaced node features, each node at each lower level having a parent node at a next higher level to which the node is related through one link;

lower level node features that share a parent node feature having centers of area positioned on the display in order approximately along a line generally parallel with the horizon with sufficiently similar spacings along the axis perpendicular to the horizon from the region around the parent node feature and with sufficiently similar spacings in a dimension generally

parallel to said horizon from adjacent node features along the line that the lower level node features sharing the parent node feature are perceptible as a group of related node features;

the second convex hulls of the first and last representations including subsets of bounded node features that represent different sets of nodes; the sequence of representations producing a perception that at least one bounded node feature has a nearest node spacing that increases from the first representation to the last representation and that at least one other bounded node feature has a nearest node spacing that decreases from the first representation to the last representation.

46. A method comprising:

obtaining node-link data defining a node-link structure;

using the node-link data to obtain layout data in a layout space having a negative curvature according to a half-plane model of hyperbolic space;

using the layout data to create a representation of said node-link structure by mapping said layout data onto a display region; and

displaying said representation of said node-link structure.

47. The method of claim 46, wherein said mapping includes compressing said layout data.

48. The method of claim 46, wherein said node-link structure includes a plurality of levels, and said mapping includes arranging nodes in the node-link structure so that nodes in a particular level in said plurality of levels lie in columns in the display region.